T1 Parametric:

The Design Process behind the Ball State University Submission of the DMTC Titanium Pedestrian Bridge Competition

An Honors Thesis (Honors 499)

Paul Lindsay

Thesis Advisor

Kevin Klinger

Ball State University

Muncie, IN

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Expected Date of Graduation

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Abstract

The Defense Metals Technology Center (DMTC) and Akron University devised the Titanium Pedestrian Bridge Competition as an opportunity to develop and present a design solution involving the use of Titanium in a commercial application. The competition, which sought primarily to highlight Titanium's incredible strength and cost-effectiveness over similar steel applications, also involved designing a solution to the logistic issue of providing a pedestrian connection above rail tracks that currently separate the University of Akron. The design solutions entail the planning of the first bridge in the United States, pedestrian or otherwise, constructed exclusively of Titanium.

This thesis seeks to detail the design process of the Ball State University Submission to the DMTC Titanium Pedestrian Bridge Competition.

Acknowledgements

Thanks to Kevin Klinger for assisting in the Thesis process and providing advice and support during the competition development. His leadership and assistance made the Ball State University Submission a reality and a success.

Thanks to David Kane and Xavier Colon for being a part of the Ball State University Submission Team and helping to produce a quality design product.

Thanks to the Defense Metals Technology Center and Akron University for devising and offering the opportunity to compete in the competition.

Thanks to Amy Evans, Adam Buente, and the Institute for Digital Fabrication Staff for support, presentation advice, and guidance during the project.

Author's Statement

The DMTC Pedestrian Bridge Competition is an excellent opportunity to effectively utilize skills developed in the undergraduate study of architecture. The design issues involve problems such as code safety, scale, structure, aesthetic value, building technology, site planning, public interaction, and programming, which are key elements in developing a successful design solution. Similarly, visual communication of the solution is a major portion of architectural study, which was a heavy focus of the competition both in the case of the graphic submission and the accompanying live presentation given to the judging panel. While the design problem, a pedestrian bridge, is not one typically attributed to an architectural design solution, the methods and design process utilized are practically identical to those involving architectural solutions.

Contents

Design Tools

A designer relies heavily on particular tools to effectively communicate ideas, diagram solutions, and work out details. This project was no different, requiring various tools to accomplish the intended result. These tools ranged from early design sketches to software for graphic presentation adjustments. The design tools used heavily influenced the design process of the project throughout the competition.

The design of the Pedestrian Titanium Bridge initially involved a great deal of conceptual work, developing practical applications of the program. This manifested itself in the use of hand sketching and quick physical mock-ups. These mediums allowed for a greater freedom of design early in the process, which allowed for greater changes to be made to accommodate changing factors and stimuli.

Because of the nature of the project as a bridge, rather than a typical architectural project like a building, programs such as AutoCAD and REVIT Architecture – which are programs typically used in architectural study – were of little real use, especially in such a design development driven phase. Secondly, these programs deal with predominantly rectangular forms, a direction the design was quickly departing from. For this reason, a modeling program called Rhino*ceros* 4.0 was utilized for its ability to quickly and effectively manage non-rectilinear geometries. The design solution was not without rectilinear aspects however, but Rhino fortunately is capable at handling both the unusual geometries as well as the more traditional (*Fig. 1*). Utilizing Rhino, the design was able to move into three-dimensional development, where both the overall form and individual components could be digitally modeled.

The design concept called for a process by which we could adjust and develop certain portions of the design in such a way that the rest of the design would respond to and adjust with the portions being changed. This demand was paramount to the design solution, but would be extremely labor intensive, as every individual piece would need to be changed to accommodate even the smallest of changes. In response, the Rhino plug-in Grasshopper was employed (*Fig. 2*). Grasshopper allows the user to script elements of the Rhino model to behave however the user dictates. This meant our scripting could allow aspects of the model to be directly altered as other elements were being re-developed (*Fig. 3-5*). This allowed the model to be generated in a much simple manner and allowed the design solution to be significantly more detailed and cohesive.

While the digital model was one method of developing and detailing the design solution, there was also a need to present it clearly as a competition entry. Adobe Illustrator became the key tool in adequately conveying the necessary graphics to present the bridge design. Utilizing this software, detailed diagrams and images were generated to be quickly recognizable with little to no text to ensure the judging panel would quickly understand the details of the design, Clients often require such graphics in architectural projects, and the situation was the same in this case.

These design tools greatly influenced how the design issues were addressed during the competition, either by directly affecting the design solution or by making the solution more understandable. In both cases, the tools necessary to complete the project were tools which involved both computer software and physical development to maximize the effectiveness of the design solution.

Design Process

The design process began with significant work on the conceptual idea of the design solution. To stand out from other competition entries, a strong and well developed concept needed to be developed and integrated from the beginning of the project. As titanium is primarily considered to be a material anchored in military technology and armed forces defense applications, the bridge would need to exhibit a fundamental tie to this idea. In the commercial sector however, titanium is notably used as an architectural cladding system. The concept became a fusion of these two ideas; defense and structure fused with the aesthetics of a paneling system. The bridge would combine the strength of a tank and the beauty of an architectural skin.

The concept was then developed into a skin, or cladding system, for the bridge that doubled as the primary structural element of the design. The merging of these two ideas generated a concept which held at its heart the goals of the competition. Such a concept would fail catastrophically were steel used instead of titanium, as weathering and the increased mass necessary to uphold the structure would slowly dismantle the bridge. The concept of the bridge comprised of a structural skin was one which celebrated titanium and stood out from other concepts.

The next step in the design development was to address site considerations and properly size the bridge. The site itself consisted of a parking lot, the railroad tracks to be spanned, and the Quaker Square Hotel. The bridge was required to provide access to either side off the railroad tracks and also provide a connection to the second floor of the Quaker Hotel. The Hotel had been converted to include Akron University Dormitories and was to be a safe connection to campus from there. This stipulation created a number of tough design issues. First, the bridge had to structurally interact with the Hotel and provide ADA (Americans with Disabilities Act) compliance from the ground floor. This meant either providing a ramp from grade up to the bridge level, or supplying an integrated elevator in the design solution. Since a ramp reaching that height would have been over

200' long, the support closest to the Hotel was outfitted with an integrated piston elevator to supply the required access in a way that worked within the overall style of the bridge. The opposite end of the bridge however, touched down inside the parking lot at the southeast portion of the site, making the ramp, which now required under half the original height due to grade change, a distinct possibility. Curving the ramp towards campus gained enough distance to adequately provide access to the bridge, while making a gesture towards the center of the Akron University campus. The curve also provided the users with more dynamic views of the surrounding site, as well as providing the bridge with greater visual presence from outside the site.

Once site concerns had been addressed, work began on the programmatic elements of the bridge. While the competition guidelines only required that the bridge offer a safe means of transport for pedestrians, the opportunity to provide areas for activity were many and convincing. As many pedestrians might use this bridge while engaging in other tasks such as socializing, we decided to provide spaces where activities might occur more naturally. For example, the connection to the Hotel broadens noticeably to allow for small group socializing and even bike storage at this area, while niches towards the center of the bridge allow for viewing the surroundings or stepping out of the walking area to take a phone call. For those seeking the fastest route across the tracks we provided an additional stair on the southeast edge of the bridge to facilitate a faster crossing. The program presented not only allowed for safe pedestrian travel over the tracks, but also provided locations for activity along the bridge itself.

The form of the building grew out of the desire for the bridge to be both visually iconic and reactive to the site. The competition guidelines required that the bridge be fully enclosed over the tracks so that pedestrian items would not fall onto the tracks, causing safety issues. For this reason, the structure narrows and slowly encloses to ensure this requirement is met. At either end of the bridge however, the structure unfolds, opening to the site in a unique and particular way. By the Hotel, the form opens to facilitate the desired previously mentioned programmatic concerns, but also widens to tie into the existing supports for the balcony. This lessens the amount of necessary material and connects the two together. On the opposite end, the uppermost portion of the bridge peels away, revealing a view to the heart of Akron University while sweeping towards its center.

The form acquired the other aspects of its shape from the unique system of parametric design. Utilizing the Grasshopper plug-in for Rhino, it became possible to develop pieces that would respond to the presence of additional pieces, meaning the design issues could be resolved with parameters that were linked to other parameters. Using this method, it became possible to generate unique pieces, each derived from an interwoven system of parts. This system of parts method created a means to employ the original concept to the bridge design. We developed a system of triangular titanium panels which could be connected together to form a skin system for the bridge. This was not the full purpose of these panels however, as they also served as the structural support for the bridge. The connections between panels were made by portions of the flat titanium panel being bent to the proper angle and bolted together to form rectangular panels. These panels were then bolted to subsequent panels to form a completed ring element. These rings were set end to end to create a tube-like structure made of interlocking triangular sections. The finished tubes work much in the same way a geodesic dome would, dispersing forces down the web members (the bent portions of the plates) to the supports at ground level. The supports are simply modified rings of the same construction which transfer the loads into the foundations. In this way the panel system which made up the skin was in fact the same piece which provided the structural support for the bridge.

However, this only resolved a single portion of the design issues involved in the bridge design. This was a method of providing structural stability in a bridge, but lacked the necessary safety handrails, views to the exterior, viable walking surface, ventilation requirements, lateral stability reinforcements, and lighting. The solution was to develop a panel system which incorporated all these parameters in such a way that one could be adjusted without destroying the possibility for another. The Grasshopper scripting we developed allowed for just that, and a system of parts became the vessel for the concept and the details of the bridge. The gaps at the apex of each triangular panel received a unique bent plate which also served as the mount for the lateral support system. This, in turn, served as the attachment point for the safety handrails and the grate system that allowed for pedestrian movement and passive snow removal (snow buildup is significantly lessened with a grated walking surface). The panels had the central, non-structural portion of the skin removed to both remove excess weight, but also allow for customizable panel inserts to be used. These could entail ventilation grating, lighting fixtures, glazing for views, or even left open if not over the tracks. These changes created a system of parts which would allow for the bridge to be made entirely out of customized interlocking parts that each operate with basic rules and relationships to one another.

The system of parts approach also allows for a significant amount of post-construction customization. The structural skin panels themselves could not be altered, but the voids within those panels could be regularly swapped out or readopted as the needs of the bridge changed. For example, if sections of Akron or the site were to become a more likely candidate for views in the future, additional glazing insert panels could be installed as desired. Similarly additional lighting could be included if necessary at specific locations to provide safety or illuminate key areas for views. We also recognized the opportunity for activity panels such as chin-up bars for possible exercise areas or information panels for public information posts. We also suggested patron recognition panels not only to help with funding, but also to create a community tie to the bridge. All of these are possible customizations to the panel system that could occur, even after construction is complete.

Construction was another issue examined in the design solution for the bridge, although a more applicable set of terms would be fabrication and assembly. The bridge, since it would be a system of parts, would be a collection of unique parts, which would mean a high level of customization in each piece. Luckily, the Grasshopper scripting could have addition scripting which would export data and cut sheets on each piece in the system. These could be sent straight to a titanium milling machine to produce all the necessary panels and connection pieces. Once finished, the pieces would be catalogued and labeled (all possible through the scripting file) and shipped to the site as 3' x3' or smaller panels. All the pieces and parts would then be assembled and bolted together on site, with fewer tools, less materials, and less labor. Admittedly, the cost of such a customized titanium system would be impressive, but scripting the operation could provide legitimate financial offsets.

Each of these aspects of the design were examined and dealt with roughly in the order presented. However, each had details which relied on other aspects of the design problem, meaning that the process involved many loops through the process, becoming more finalized each time. This feed-back loop was essential in the design process and was another example of the parametric design strategy utilized. Each time through, different parameters would be evaluated and adjusted, which would affect the other parameters, until all the parts were in sync with one another.

Presentation and Graphics

With a successful design solution achieved, it became important to be able to communicate this solution to the panel judges. The initial submission included a several preliminary renderings, a site plan, two quick experiential sections, and a submission essay, but this was only the submission for the first round. The Ball State University Team was awarded a finalist position and asked to submit a new presentation to be given to a panel of judges in Akron, Ohio. In the initial submission it was important to illustrate a successful concept or driving theme and aesthetic value. However, in the second round it was important to explain the system of parts and assert the project's feasibility.

Layout became a key design issue at this point. It was absolutely necessary to successfully communicate the design solution and its process as quickly and effectively as possible, so as to open the presentation to questions more quickly. Time was a constraint, with only 20 minutes maximum for presentation and the remaining time not used to be a question and answer session. To maximize the effectiveness of our submission and presentation there needed to be a highly organized set of information to fully explain the system of parts and, through that, the entirety of the bridge.

The presentation graphics (see Appendix B) begin with a 'refresher' portion, intent on reminding the panel of the conceptual basis for the design while providing a quick look at aesthetics and site design. The second panel and third panel offer an enlarged elevation and sections to briefly explain and illustrate the form and style of the bridge. These serve to give an overall view of the design, which the presentation would then begin to focus into, getting more and more detailed as the presentation progressed before panning back out to a larger view for reference. The diagrams on the third panel begin this process, enlarging a small area from one of the sections. This diagram is annotated slightly to call out some of the adjustable parameters of the system of parts. The second diagram is a detail of several of the panels from the previous diagram and explains the method of attaching the panels together to form the structural network. From here we begin to zoom out, examining how the panels begin to form ring sections which, in turn, connect to adjacent rings on the fourth panel. In this section there is also a diagram explaining the various customizable inset panels and their significance. The final diagram takes us out far enough to view a section of the foundation detail and how the integrated elevator might function. With this progression, the system of parts idea is presented to allow for a quick understanding of the principle with less annotation and explanation. Simple renderings and line drawings are utilized here to keep the graphics simple and tell a concise story of how the parts come together.

The style of the boards was also of significance for the competition. The DMTC color palate features a light blue, as does the Akron University logo. This made for a unique accent color for the boards that highlighted the brightness and relative weightless aspect of titanium in comparison to steel. The diagrams and renderings were kept as simple as possible to accentuate the reflectivity and polish of titanium while also maintaining the elegance of the design solution.

The panels were printed and mounted for the presentation in Akron, Ohio, using a glossy print in an attempt to give the titanium in the renderings a mirror effect. The verbal presentation focused on explaining the intricacies of how the bridge was designed using the parametric system and could be implemented successfully using a similar system. Attention was paid to each aspect of the design process to inform judges of the rigor of the design solution. Questions about the bridge design included a brief question on snow removal and the possible application of structural software to examine exact structural stability. Preliminary examination could be done using the software Autodesk Robot. After these questions, the presentation was closed and boards submitted while the judging panel made its decision. This presentation was given at the second round of submissions and will determine the results of the competition between the five submission finalists.

Conclusion

The design solution that was finalized and presented to the DMTC Titanium Pedestrian Bridge Competition judging panel was one that focused on the fusion of the characteristics of an Armed Forces tank and an architectural cladding system and was accomplished using a complex system of parts developed based on parametric modeling using Rhino plug-in Grasshopper. The design solution takes into consideration the complexity of site concerns, programming, structure, aesthetics, code requirements, customized parts, fabrication, and assembly in an elegant and simple design strategy that has allowed it to advance into the next stage of judging in the DMTC Titanium Pedestrian Bridge Competition.

The competition results will be announced May 20th 2010 in Akron, Ohio.

Figures

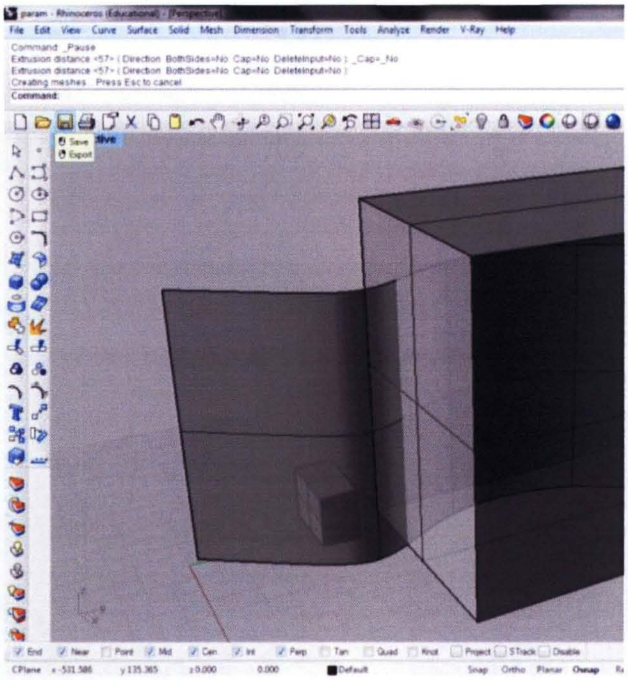

Figure 1: A Rhino*ceros* 4.0 interface and model

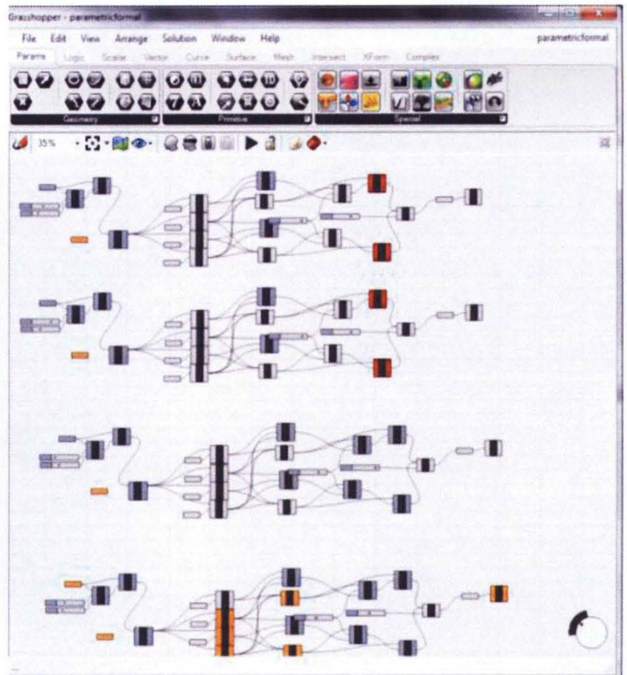

Figure 2: A Grasshopper interface and the project script

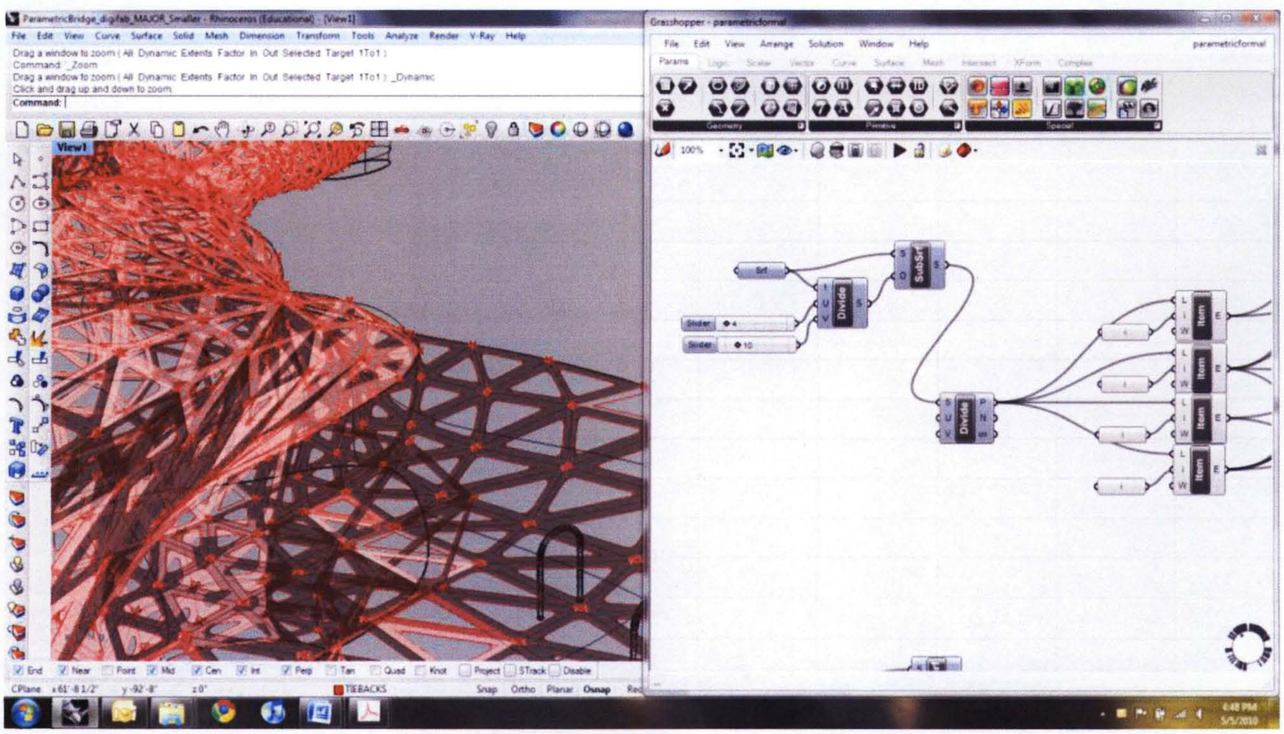

Figure 3: Developing a triangulated surface in Rhino using Grasshopper scripting

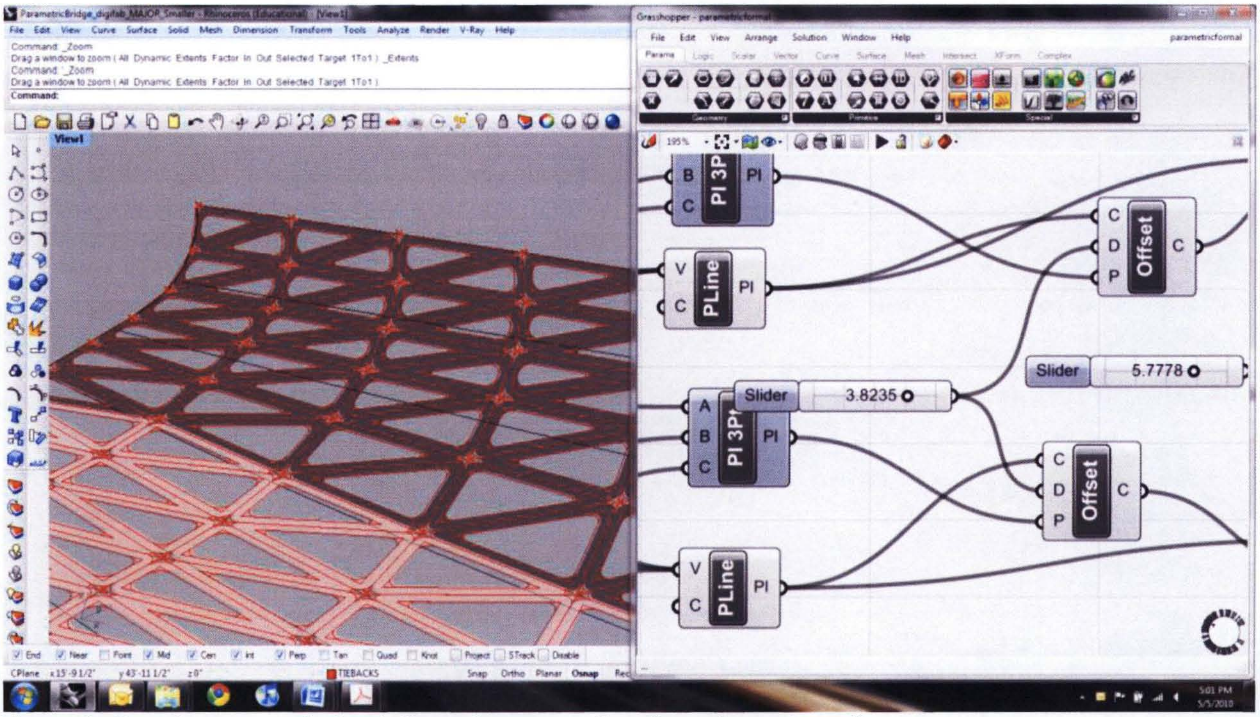

Figure 4: Grasshopper scripting influencing a set of surfaces (seen in red)

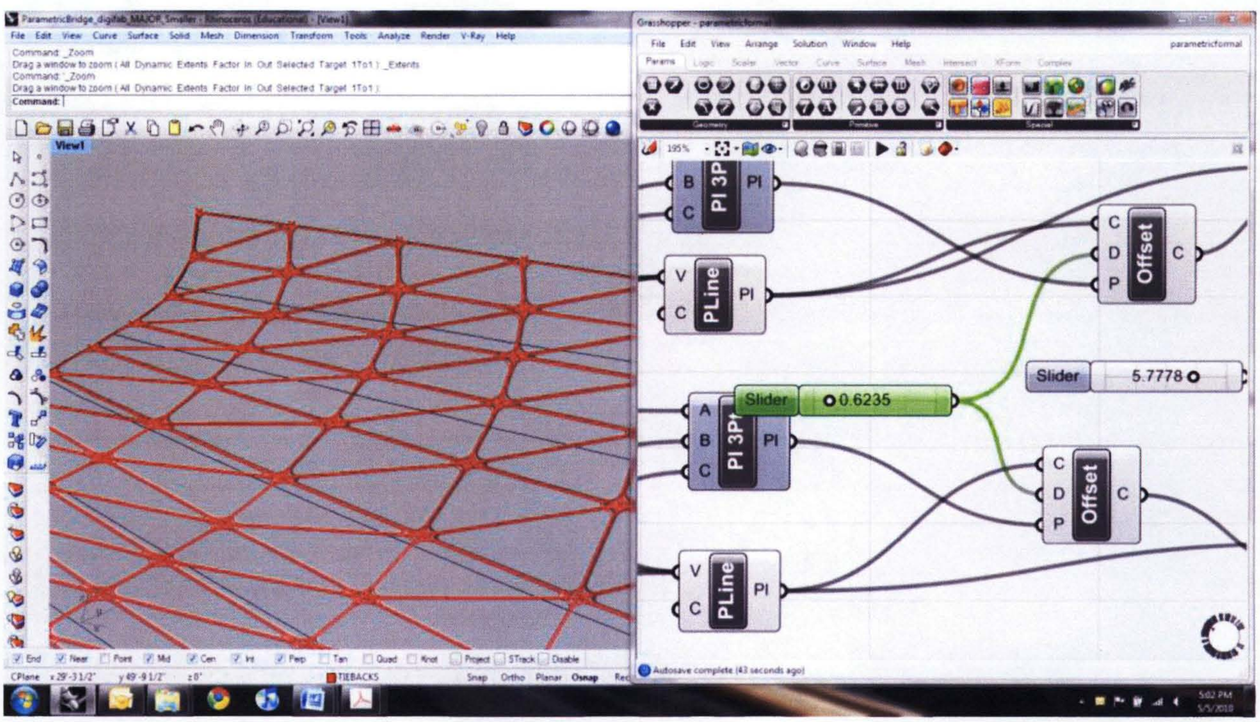

Figure 5: Grasshopper scripting altered to adjust all networked surfaces (seen in red) in relation to each other by use of a slide bar (seen in green)

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Appendix A

The DMTC Titanium Pedestrian Bridge Competition Guidelines

Design THE Future

TITANIUM Pedestrian Bridge Design Competition

Demonstrate
the Advantages
of the *wonder* metal
Titanium
and Compete
for Student
and Institutional
Awards

Sponsored by
The Defense Metals Technology Center
and
The University of Akron

www.defensemetals.org

Design THE Future

June, 2009

Dear Prospective Participants –

The Defense Metals Technology Center (DMTC) of North Canton, Ohio and The University of Akron devised this unique Student Pedestrian Bridge Design Competition with two imperatives:

- To demonstrate the use of cost-effective Titanium as an alternate to steel in significant commercial applications.
- To show that Titanium is a realistic alternative to steel in bridge construction and rehabilitation, which is a fundamental national infrastructure issue.

There also will be a practical impact. That is solving a logistical quandary by designing a pedestrian bridge over railroad tracks that divide The University of Akron campus.

Where better to find skilled competitors than from Civil Engineering, Architecture, and Industrial Design departments and schools of qualified universities in the *Metals Heartland of America:* Ohio, western Pennsylvania, eastern Indiana, southeast Michigan, northern Kentucky and northern West Virginia.

By participating in this demonstration project, you will learn about and propose an application for what we believe will be the first bridge anywhere constructed exclusively of Titanium.

At the same time, the winning designs should attract widespread public attention and frame your future résumé.

There is also an attractive scholarship incentive for the winning students and institutions. See Page 15.

The success of the Student Pedestrian Bridge Design Competition should contribute to a much better understanding of the potential commercial applications of Titanium. In turn, this should create more demand for Titanium and initiate more production at lower prices. The anticipated outcome: the increased ability of the U.S. military to use more life-protecting Titanium in armaments.

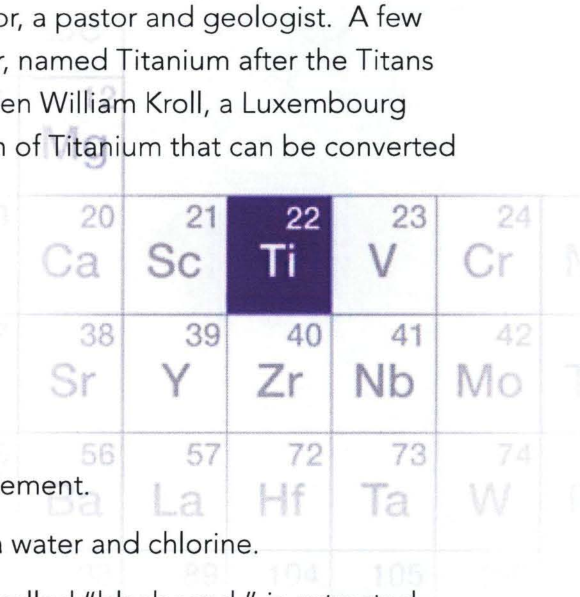
This brochure will explain the background and rules of the Competition. We invite your participation – as teams of students and academic advisors representing your institutions – and wish you good luck.

Charlie Clark
Executive Director
The Defense Metals Technology Center

Ted Curtis, AIA, NCARB
Vice President of Capital Planning and
Facilities Management, The University of Akron

Titanium: Its Amazing Possibilities

Titanium was discovered in 1791 in England by William Gregor, a pastor and geologist. A few years later, Martin Heinrich Klaproth, a German chemistry professor, named Titanium after the Titans of Greek mythology. A modern-day breakthrough came in 1938 when William Kroll, a Luxembourg metallurgist, discovered a commercial process to make a pure form of Titanium that can be converted for industrial use.



Titanium:

- Is the fourth most abundant metal in the earth's crust.
- Is 45 percent lighter than steel, but just as strong.
- Is 60 percent heavier than aluminum but twice as strong.
- Has the highest strength-to-weight ratio of ANY known element.
- Does NOT rust and is corrosion-resistant, including to sea water and chlorine.

Black Sand

Titanium oxide, often called "black sand," is extracted from the earth as rutile and ilmenite ore. The chemical process to convert the raw material to usable metal is expensive, as opposed to the less costly heat-and-pressure process used to extract iron from ore to make steel.

"Titanium is a marvelous metal that can enhance protection of our military while contributing significantly to the economy of America's Metals Heartland," says retired Congressman Ralph Regula of Navarre, Ohio.

Sponge

The intermediate raw material, known as "sponge," is porous metallic Titanium, which is crushed and pressed before it is melted in an arc furnace. The melted ingot solidifies in a vacuum. It is often remelted to ensure uniformity. These steps add to the cost of the product.

Titanium Plate

Titanium can be significantly more expensive than stainless steel; however, it can be alloyed with various elements, including iron, aluminum, and vandadium. It is commonly used in the aerospace industry, orthopedic implants, dental instruments, golf clubs, bicycles, and jewelry.

It is even used in structural design. In fact, innovative architect Frank Gehry used Titanium in his best known work, the Guggenheim Museum in Bilbao, Spain. The museum's undulating exterior is sheathed in more than 375,000 square feet of Titanium.

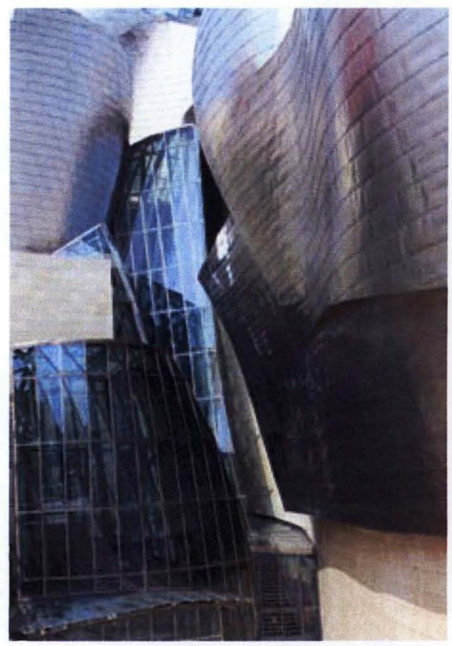
The experimental Cormorant currently being tested by the Navy is made of Titanium and other advanced materials.

What is more, columns supporting the famed Parthenon in Greece were recently restored with Titanium rebar, plates, and fasteners. They replaced 30-year-old steel supports from a previous restoration that had rusted.

The military has a desire to utilize more Titanium, but this expanded usage is limited by cost and availability.

Still there are some important current military applications. Titanium is easier to bend into shape and more protective than steel. Accordingly, shields on motorized combat equipment, such as Humvees, are now made from Titanium providing better defense against Improvised Explosive Devices (IEDs).

Because of greater profitability, American companies since the end of World War II have focused on manufacturing high-end aerospace-grade Titanium and not armor-grade Titanium.



The Guggenheim Museum in Bilbao, Spain sheathed in Titanium.

Throughout the Cold War, the Department of Defense relied heavily on Titanium in advanced aircraft, such as the SR-71. Lockheed made the super-secret spy plane SR-71, which was 90 percent Titanium. Radar-absorbing and travelling at three times the speed of sound, the reconnaissance SR-71 was retired in 1985 because of its high operation costs.

A Titanium ingot heated and ready for processing into usable metal.

The Soviet Union could not match the extraordinary U.S. Titanium-laden aircraft. Yet today the largest producer of Titanium metal is a Russian company, which accounts for almost a third of the world market share. Many countries have significant Titanium ore deposits, including the United States.

Some years ago, *BusinessWeek* recognized the characteristics of Titanium in an article entitled **A Magic Metal for the Masses**, noting that Titanium "had earned its reputation as a wonder metal at the dawn of the Space Age."

The Defense Metals Technology Center and its Role In *America's Metals Heartland*

This Pedestrian Bridge Design Competition is intended to demonstrate the astonishing qualities of Titanium in meaningful civilian purposes.

As it does not rust or corrode and is more protective than steel, this Design Competition should also help highlight Titanium's viability and – we anticipate – its long-term cost savings in military applications.

The need to promote the potential of specialty metals – most importantly Titanium – was the driving force behind Congressional funding of The Defense Metals Technology Center (DMTC) as a Center of Excellence, beginning in 2007.

The mission is to establish an organization that can be uniquely responsive in dealing with critical technology that impacts the military's metals needs. Among the DMTC goals: invigorating an industrial base capable of producing affordable strategic metals.

The Titanium-built SR-71.

Spearheaded by U.S. Representative Ralph Regula of Navarre, Ohio, the Center was appropriately positioned on the campus of Stark State College in North Canton – the midpoint of *America's Metal Heartland.*

Charles D. Clark is Executive Director of The Defense Metals Technology Center. He has extensive experience in corporate management, technology transfer, and government projects.

Among the responsibilities of the Executive Director is meeting with metals companies to explain how they can profit from manufacturing Titanium-based products.

With funding from the Department of Defense Appropriation Act and the Ohio Department of Development, it was natural for the Defense Metals Technology Center to sponsor a Student Titanium Pedestrian Bridge Design Competition nearby with The University of Akron.

"A return to this American tradition of experiments and design contests also will rebuild competition in the U.S. defense-industrial space," says P.W. Singer, a Senior Fellow at the Brookings Institution, in his recent book, ***Wired for War: The Robotics Revolution in the 21st Century.***

Akron – From Rubber City to Polymer City

Akron has been known for more than a century as the Rubber City.

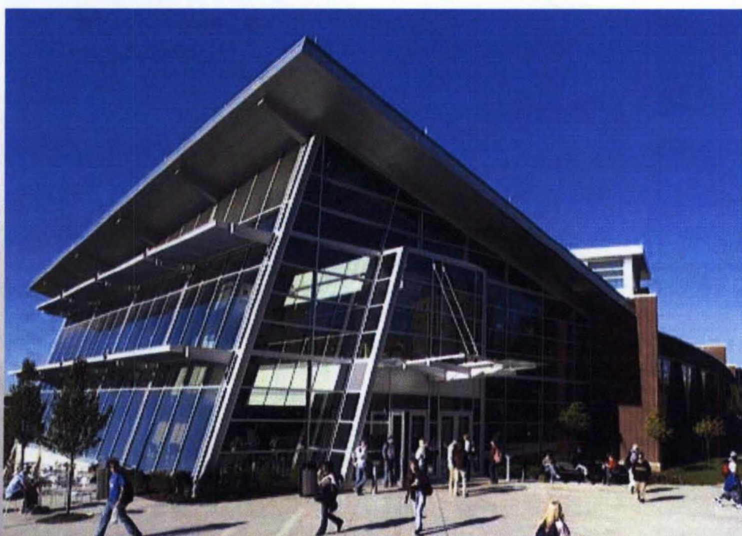
As rubber has contracted in recent years, Akron – adjacent to Canton in *America's Metals Heartland* – has transformed itself into the global center of polymer research and manufacturing.

And by embracing this unique competition, Akron may well experience another technological dawn.

The competition surely will impact The University of Akron and intensify its role in the worldwide application of advanced materials.

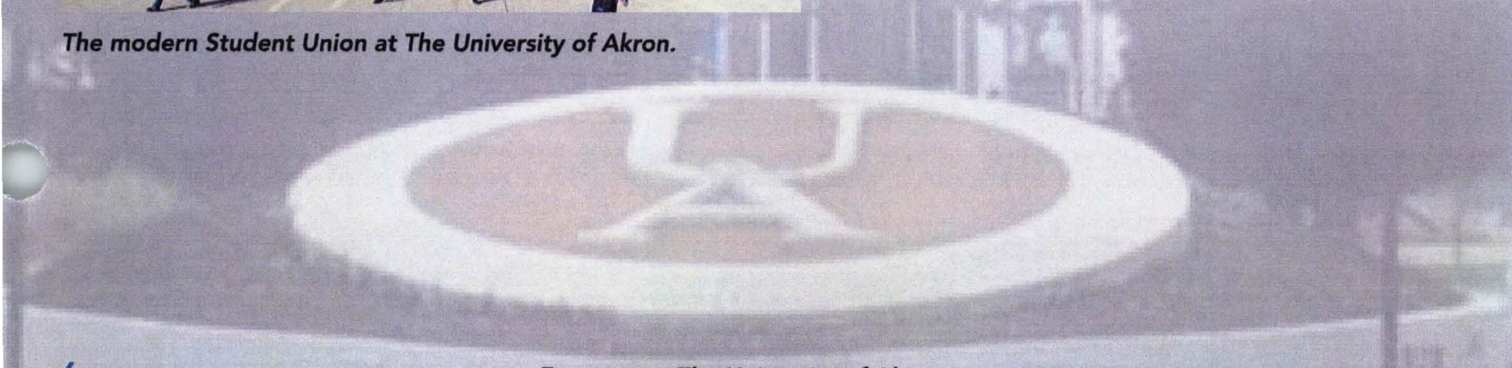
The University has expanded in recent years on its 222 acres. To meet a student enrollment that is rapidly growing beyond 26,000, the University is faced with increasing logistical challenges. Hence, it has a strong practical interest in participating in this important demonstration project.

The Dale Chihuly polymer sculpture at the Goodyear Polymer Center at The University of Akron.



The modern Student Union at The University of Akron.

"We welcome the opportunity to participate in this demonstration project with the Defense Metals Technology Center," says Dr. Luis M. Proenza, president of The University of Akron. "A Titanium bridge will continue to reflect the innovative and entrepreneurial spirit we engender on our campus."

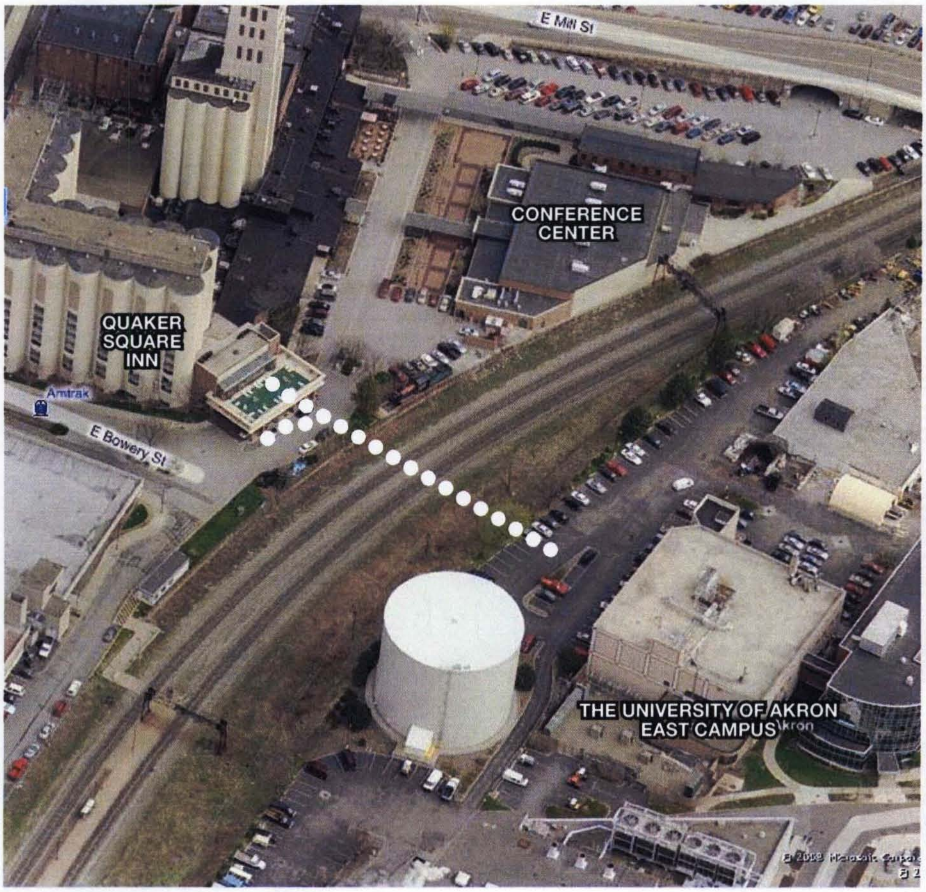


Entrance to The University of Akron

The Challenge: Bridging the Tracks

U.S. Representative Ralph Regula put it bluntly in an *Inside Business* magazine article not long ago about the Minneapolis bridge collapse in 2006. "If the bridge had been built of Titanium, or at least the important components," he said, "I think it would be still standing, because Titanium is impervious to rust."

DMTC Executive Director Charles Clark, working with Ted Curtis, The University of Akron Vice President of Capital Planning and Facilities Management, devised this Bridge Design Competition.



Aerial view of the proposed bridge site.

Not only is the Competition aimed at demonstrating the attributes of Titanium, the practical objective is solving a logistical dilemma at the University. This is building a pedestrian bridge linking one side of the campus to another across busy tracks.

The tracks separate the main campus from Quaker Square, a popular landmark that once was a Quaker Oats mill complex. Quaker Oats built the storage facility in 1936 and, until 1970, stored grain in its silos, which was delivered by rail.

In the late 1970s, the 36 silos – each 120 feet high and 24 feet in diameter – were converted into Quaker Square, enclosing a Hilton Hotel, along with a retail/ restaurant complex. The idea came from Ted Curtis, co-administrator of this Design Competition.

Curtis envisioned a complex in Akron much like Ghirardelli Square in San Francisco – a modern retail adaptation of an abandoned industrial complex. He brought in such prominent investors as movie stars Gregory Peck and Karl Malden and comedian Flip Wilson, and Quaker Square was listed in the National Register of Historic Places.

The Quaker Square Inn viewed from the main campus.

As part of its continuing investment in the revitalization of the surrounding neighborhood, The University of Akron in 2006 purchased Quaker Square (by then a Crowne Center Hotel) and converted 100 of the hotel rooms into student dormitory space. The remaining hotel rooms are now known as the Quaker Square Inn at The University of Akron.

From the Inn, one can look across the CSX tracks to the Main Campus, including the University's celebrated E.J. Thomas Performing Arts Hall.

To access the Main Campus, however, students must walk several hundred yards south or east to conventional street bridges. More audacious Quaker Square residents jump a wire fence, dash down a gully, and scurry across over the tracks. With numerous trains speeding by daily, this contrivance is hazardous – and a growing concern to the University as well as CSX.

Entrance to the Quaker Square Inn.

On the Quaker Square side, the Bridge Design that can address this logistical challenge will need an entrance/exit on the second-floor interior of the Inn.

The bridge also will require a separate entrance/exit at the exterior ground-level parking area of the Inn. This must be easily accessed by a pedestrian ramp.

To link to the Main Campus – the east side of the University – the bridge (some 200 feet in length) should be designed to slope appropriately across the tracks into an open parking area.

Arrow indicates the area to be spanned by the proposed Titanium bridge.

A practical objective is solving a logistical dilemma: designing a pedestrian bridge linking one side of the campus to another across busy tracks.

Important Questions and Answers

Q. Why a Student Design Competition?

A. University student design competitions are recognized as a practical method to address engineering, scientific, and environmental challenges. Design competitions provide students with real-world experience that they can transfer into their professional lives. In addition, using students to create a first-class design will solve a logistical problem for pedestrians on The University of Akron campus.

Q. Why Titanium?

A. The DMTC wants to increase knowledge about the attributes of Titanium, thereby enhancing both its commercial and military use. This Pedestrian Bridge Design Competition is also in line with the DMTC mission to train engineers in the use of specialty metals.

Q. Why the University of Akron?

A. Akron is in the *Metals Heartland of America.* The University of Akron is known for its research in polymers and other important materials. Likewise, it was instrumental in establishing the DMTC. At the same time, it also has a serious logistical challenge.

Q. What criteria will the Selection Committee use in selecting winners?

A. These include practicability, design in concert with the bridge surroundings, and conservative approach to construction cost.

Q. Are there any required specifications?

A. All bridge components must be Titanium, including rebar and fasteners.

Q. What universities are eligible to enter the competition?

A. Applications are welcome from departments and schools of architecture, civil engineering, and industrial design in *America's Metal Heartland*, the operational footprint of the DMTC. The area is Ohio, western Pennsylvania, eastern Indiana, southeast Michigan, northern Kentucky, and northern West Virginia.

Q. How must the Student Design Teams be comprised?

A. The Design Team can have up to four students. They must be full-time degree-seeking undergraduate or graduate students and enrolled in good standing at their sponsoring academic institution. Their tuition must be paid by the students or family, by scholarship, or with the aid of an American government agency, American corporation, or American nonprofit institution, or government loan.

Q. Who can serve as Faculty Advisor?

A. The Faculty Advisor must be at least an Associate Professor, who is employed full time in the school or department sponsoring the Design Team.

Q. Who sits on the Project Review Panel?

A. The DMTC and The University of Akron will select civically involved local citizens.

Q. Will there be an Awards Presentation for the winning teams?

A. Yes, promptly after the winning designs are selected. The winners will be announced at a dinner for the finalists. The monetary awards also will be presented at that time.

Q. Once the Design Competition is completed, will the bridge be built?

A. There is a clear need for this bridge! Funding efforts will begin as the Design Competition is achieving full momentum.

Q. How will construction be funded?

A. State, federal, and private funding will be sought. This competition is viewed as an infrastructure need, as well as a demonstration that should stimulate publicity and construction interest.

Q. Can the application be submitted on-line?

A. Yes. Go to www.defensemetals.org.

Application

(Page 1 of 2)

Send to:

Titanium Bridge Design Competition
c/o The Defense Metals Technology Center
6200 Frank Avenue NW
North Canton, OH 44720

Date ________________

or on-line:
www.defensemetals.org

Summary of qualifications should include a description of who will participate on the team – both professors and students – and their background.

Institution ______________________________

Department of School ______________________________

Institution President or Dean ______________________________

____

____

Phone ________________ Fax ________________

Email ______________________________

Project Supervision

In support of this Student Design Competition, I herby endorse this grant application and commit to serving as the primary supervisor of our team.

Faculty Advisor ______________________________

Title and Qualifications ______________________________

____

____

The Faculty Advisor must be at least an Associate Professor, who is employed fulltime in the school or department sponsoring the Design Team.

Institution ______________________________

Student Design Team

The Design Team can have up to four students. They must be full-time degree-seeking undergraduate or graduate students enrolled in good standing at their sponsoring institution. Their tuition must be paid by the students or family, by scholarship, or with aid of an American government agency, American corporation, American nonprofit institution, or government loan.

1. Name ______________________________

   Social Security Number ______________ Student ID Number ______________

   Class Standing and Qualifications ______________________________

   ____

   Address ______________________ Email address ______________

2. Name ______________________________

   Social Security Number ______________ Student ID Number ______________

   Class Standing and Qualifications ______________________________

   ____

   Address ______________________ Email address ______________

3. Name ______________________________

   Social Security Number ______________ Student ID Number ______________

   Class Standing and Qualifications ______________________________

   ____

   Address ______________________ Email address ______________

4. Name ______________________________

   Social Security Number ______________ Student ID Number ______________

   Class Standing and Qualifications ______________________________

   ____

   Address ______________________ Email address ______________

Design THE Future

Timetable

June 2009 – Applications to be sent by FedEx to the President or Dean of qualified institutions.

October 2, 2009 – Deadline for institutions to submit an application.

October 16, 2009 – Selection Committee will send Notice of Acceptance by email.

October 29, 2009 – Site tour, orientation, lunch, question-and-answer session at Quaker Square Inn, The University of Akron. Arrive by 10 a.m.

January 29, 2010 – Deadline for submitting basic drawings, digital model, and a brief essay describing the concept and features of the proposed bridge design.

February 26, 2010 – Judges will select five finalists and notify teams of their decision.

April 9, 2010 – Deadline for finalists to submit physical models and full specifications.

May 6, 2010 – First Place and Second Place Winners, as well as three teams receiving Honorable Mentions, will be announced at a special dinner and awards ceremony for finalists.

Mail Applications to:

Titanium Bridge Design Competition
c/o The Defense Metals Technology Center
6200 Frank Avenue NW
North Canton, OH 44720

Or on-line at: www.defensemetals.org

Selection Committee

Lillian A. Kuri
Program Director for Architecture,
Urban Design and Sustainable Development
Cleveland Foundation

Job H. Lippincott
Publisher
RubberWorld Magazine
Akron

Hon. Ralph Regula
Retired Congressman
16th Ohio District
Navarre

Victor J. Scaravilli
Chairman and CEO
Mole Constructors Inc.
Pepper Pike, OH

Paul Thomarios
President
Thomarios Companies
Akron

Ex Officio

Charlie Clark
Executive Director of the
Defense Metals Technology Center

Ted Curtis
Vice President of Capital Planning and
Facilities Management, The University of Akron

Special Advisor

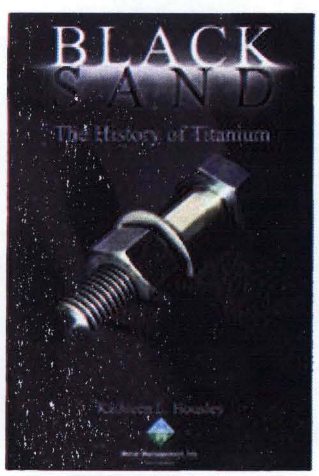
Gary Nemchock
President
Architectural Titanium
Lawrence, Kansas
Fax: 785.842.9944
Email: gary@architecturaltitanium.com

Nemchock has been retained by the Selection Committee to be available to the Design Teams to provide direction and assistance on questions about Titanium resources and specifics.

He WILL NOT provide design guidance.

Nemchock is a consultant on the strategic development of worldwide applications for architectural Titanium. He is also president of his own company, Architectural Titanium.

Nemchock has over 25 years of experience in custom architectural metals and has made hundreds presentations on architectural metals to the world's leading architect and design firms and university architecture programs.



Recommended reading: *Black Sand: The History of Titanium*, written in 2007 by *Titanium News* editor Kathleen L. Housley. This is the definitive history of Titanium discovery, processing, usage, and possibilities.

Critical Stipulations

- All components of the bridge must be made of Titanium, including rebar and fasteners.
- The Titanium to be used must be obtainable from American manufacturers. Where there is no American source, alternative imported sources should be recommended.
- State-of-the-art accessibility must be built into the design.
- The Bridge Design must be practical, feasible, and affordable. It also must have aesthetic attributes that will make it a campus and community landmark.

Awards

The judges will select a First Place and Second Place winner, as well as three Honorable Mentions. The accompanying financial awards will be distributed in the following manner:

Students – The money will be disbursed to each student (up to four members per team) as a scholarship for ongoing education or for payment of loans incurred in pursuit of an engineering, design, architecture, or other relevant degree. Each winning student will be required to document that funds were used in accordance with the rules, intent, and spirit of the Pedestrian Bridge Design Competition.

First Place – $5,000 per student

Second Place – $3,250

First Honorable Mention – $1,750

Second Honorable Mention – $1,250

Third Honorable Mention – $1,000

Institution – Financial awards will be disbursed to the academic departments of the winning teams.

First Place – $5,000

Second Place – $3,250

First Honorable Mention – $1,750

Second Honorable Mention – $1,250

Third Honorable Mention – $1,000

Each Faculty Advisor will oversee the institutional award to insure that it is applied to support student research and/or the direct study of the use of specialty metals, including Titanium, in new commercial applications.

The Faculty Advisor will report to the Defense Metals Technology Center about the use of the institutional grant.

Rights

All designs and specifications supplied by Pedestrian Bridge Design Competition applicants will become the joint property of The Defense Metals Technology Center and The University of Akron for their exclusive use and dissemination.

The Defense Metals Technology Center
6200 Frank Avenue NW
North Canton, OH 44720
330.305.6605
www.defensemetals.org

The University of Akron
Capital Planning and Facilities
Management
Facilities Planning and Construction
Lincoln Building, Suite 325
Akron, OH 44325
www.uakron.edu

Appendix B

The Ball State University Submission Material for the DMTC Titanium Pedestrian Bridge Competition

T1 Parametric

T1 Parametric - pedestrian bridge
ponsored by the
Defense Metals Technology Center and the
Jniversity of Akron, in Akron, Ohio

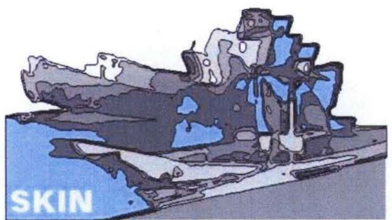
/iewable from multiple locations, the bridge stands out as an icon to the city, the DMTC, and the University of Akron. The bridge serves as a connection between reater Akron and the University, linking the northern edge of the campus to the city ver the existing rail.

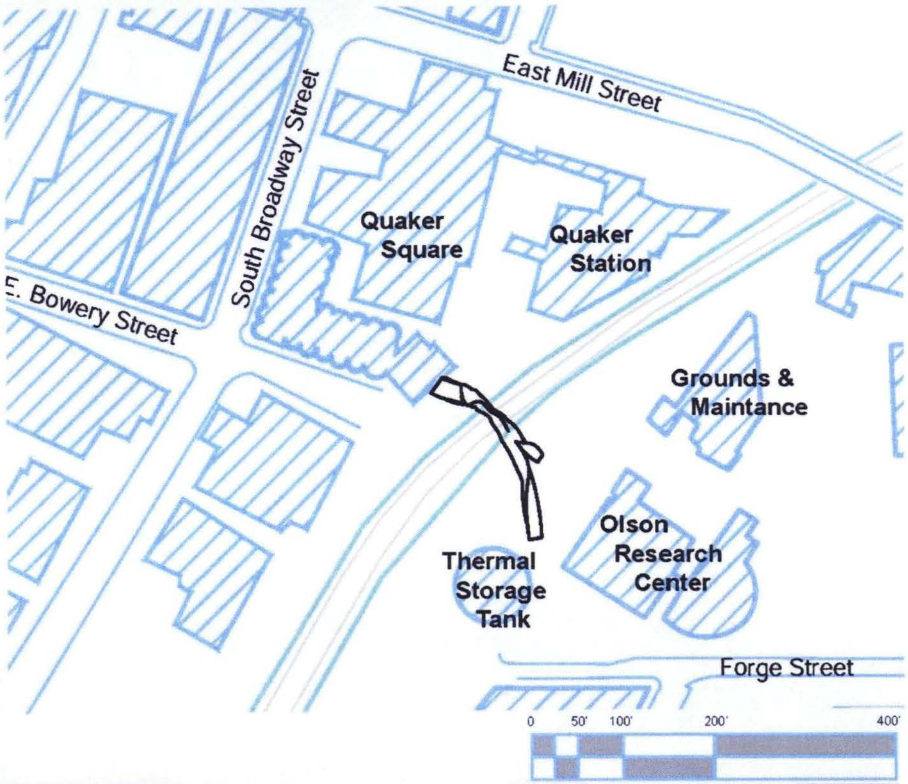
he implementation of titanium typically involves defense or structure, as in the case f military equipment, otherwise it is used architecturally or aesthetically, as in a ladding system. The T1 Parametric bridge combines both of these ideas into one - he strength of the tank and the aesthetic of a beautiful architectural skin.
Skin = Structure.

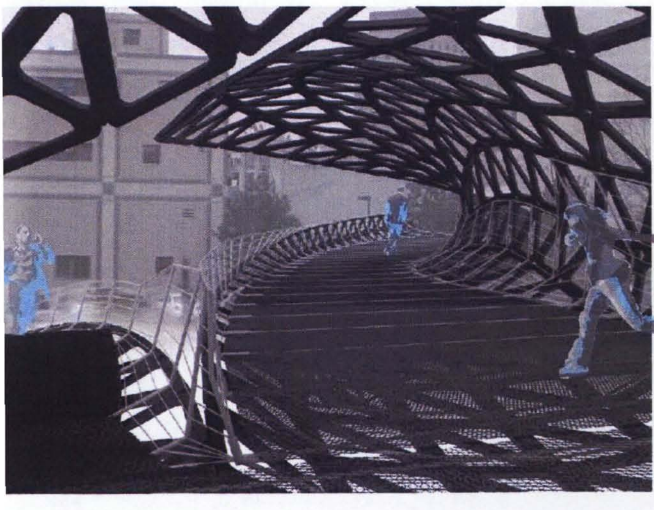
he skin of the bridge itself has been parametrically generated and each subsequent kin panel then folded to create a structural panel. These panels are bolted together o form structural rings that transfer loads back to the vertical supports integrated nto the foundations. This combination of the skin and structure allows for a clean ppearance that compliments the light and yet an extremely strong nature of Titanium

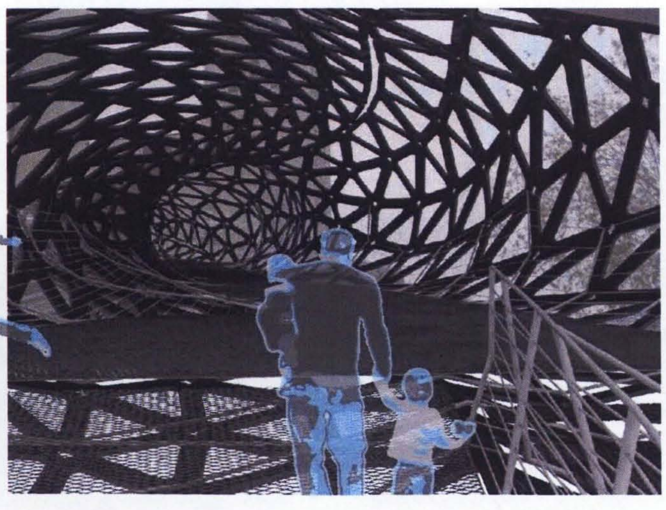
hese panels also serve as highly customizable units which may receive a variety of ifferent treatments. This may include integrated lighting, ventilation, glass enclosure, nd information/exercise fixtures. This allows the bridge to accommodate changes in se or technology over time.

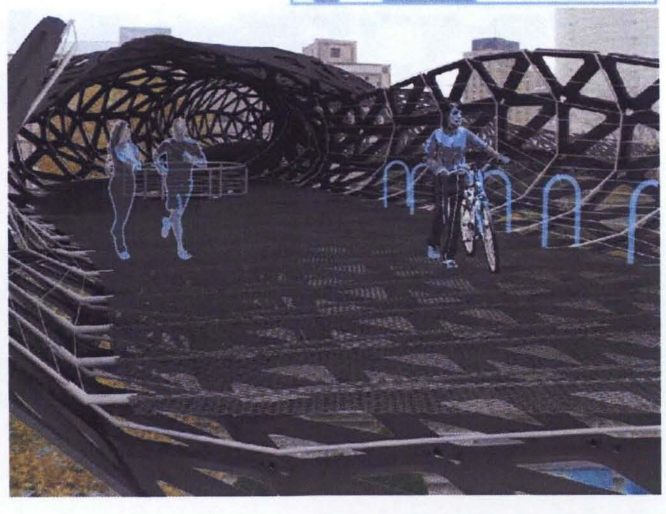
+

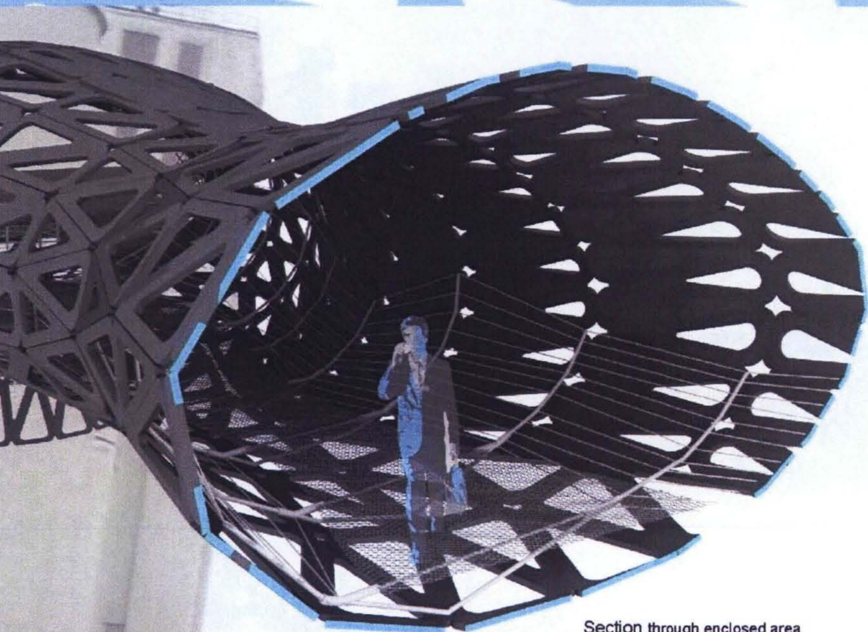


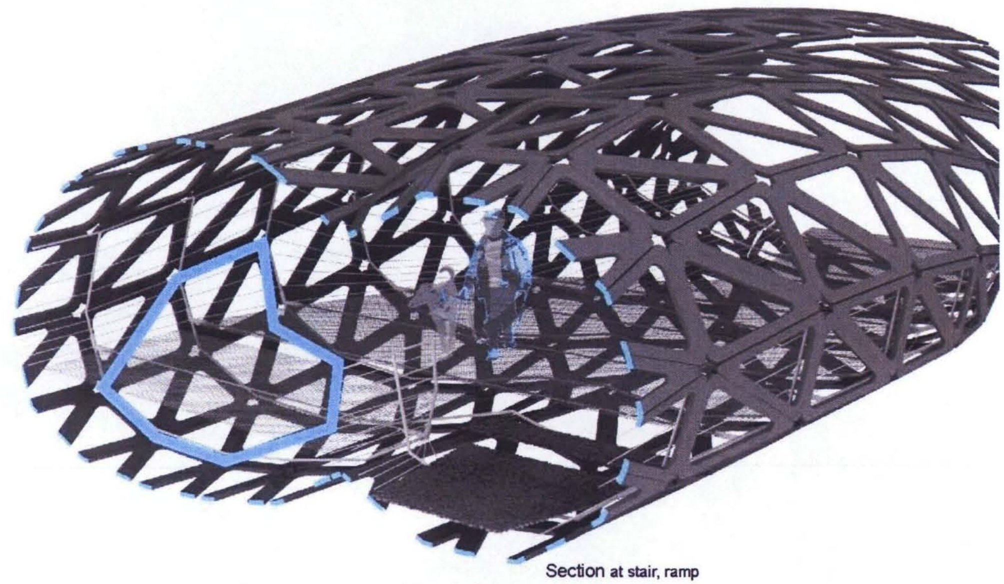


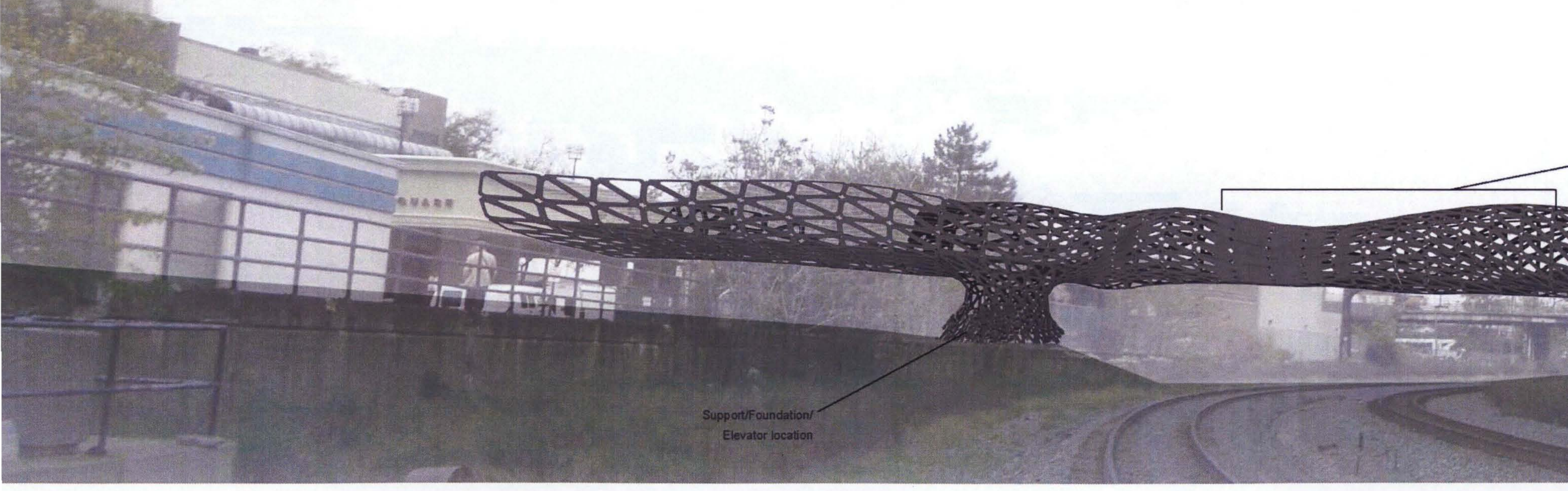


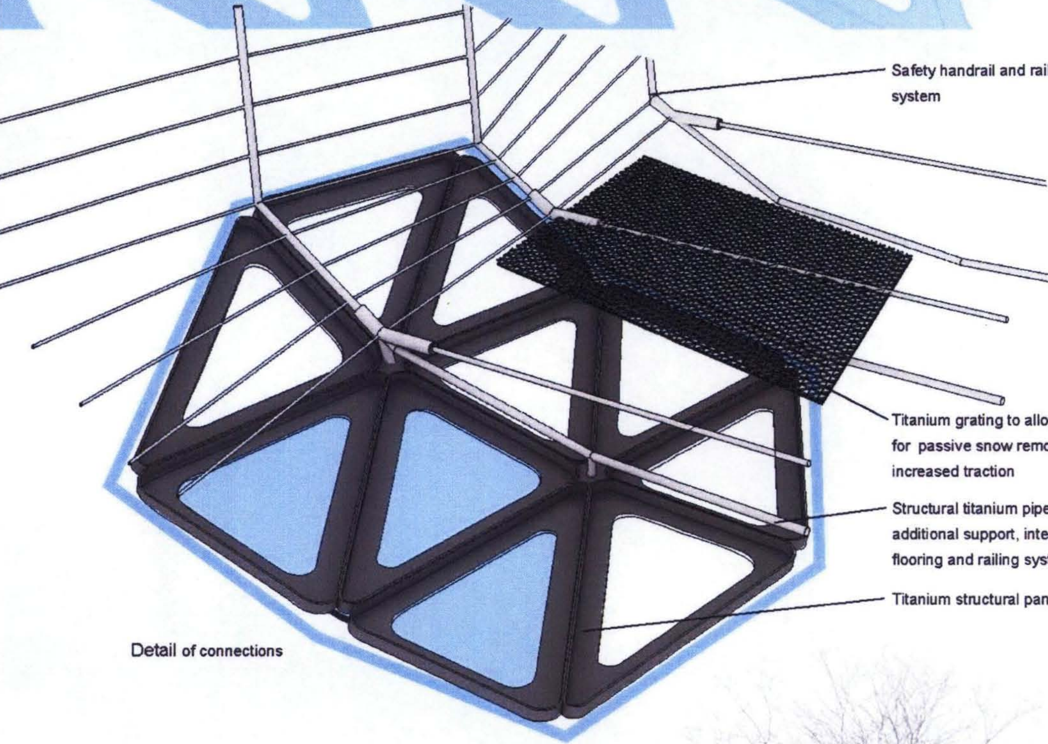




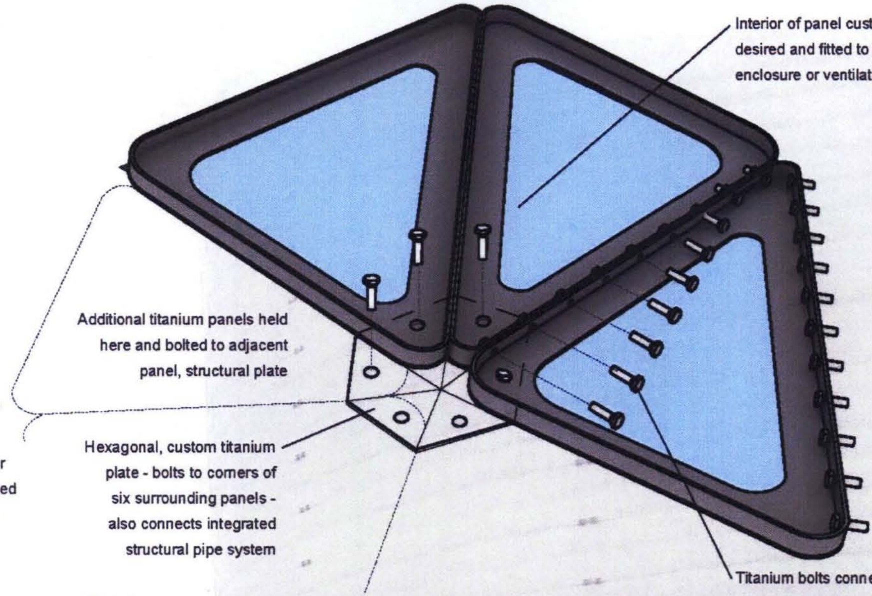

Section through enclosed area


Section at stair, ramp

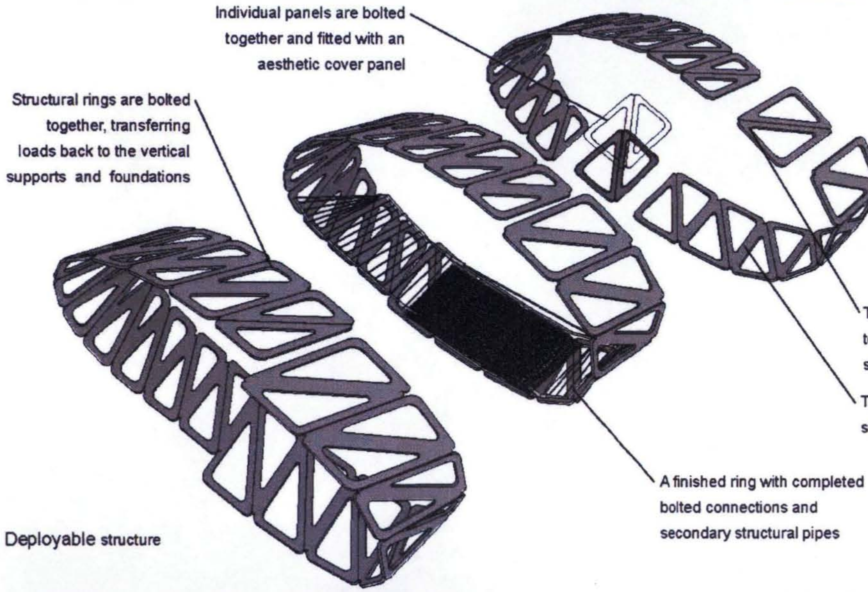




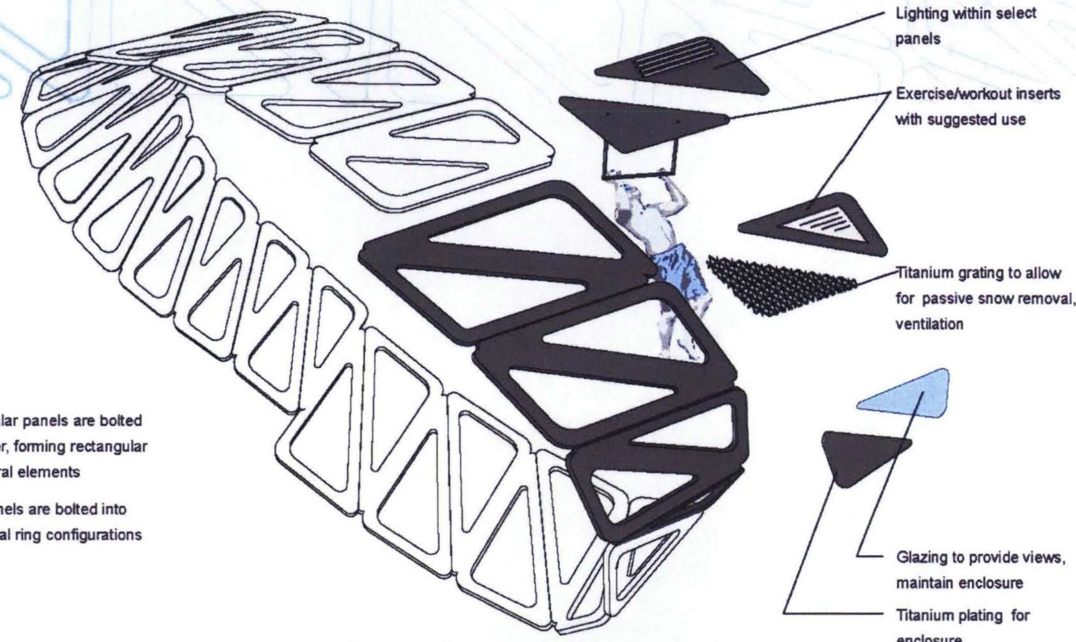
Detail of connections



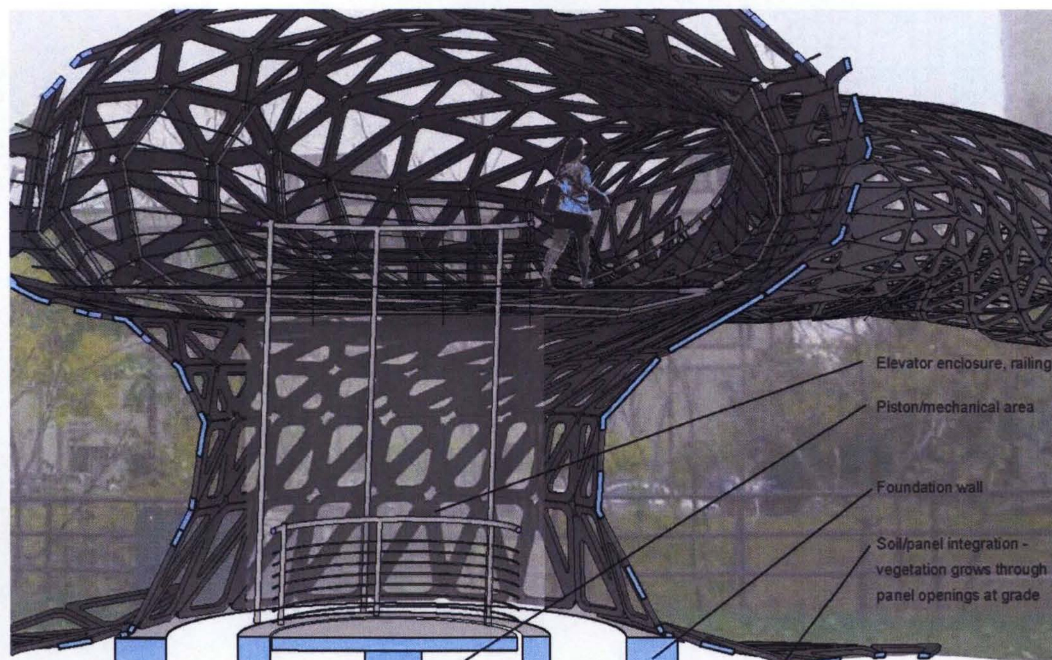
Detail of panel connection



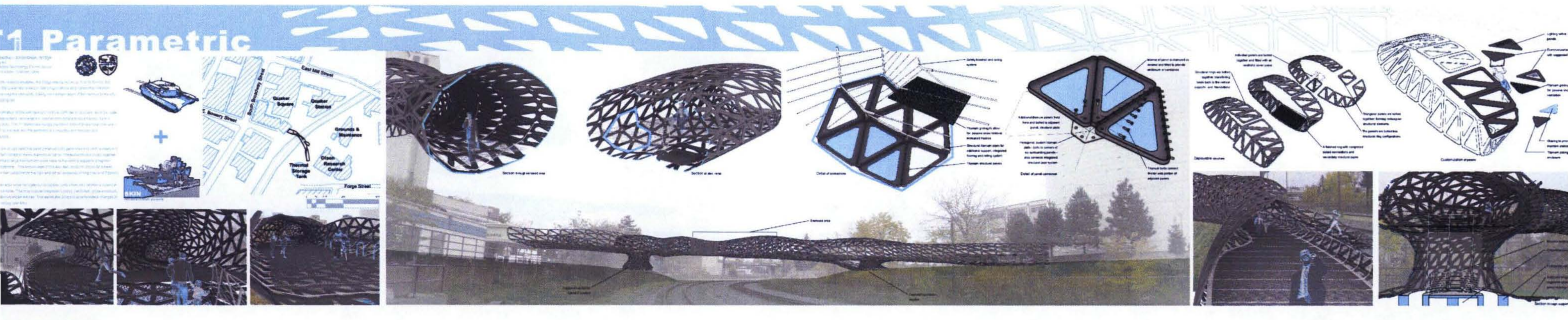
Deployable structure



Customization of panels



Section through support/elevator


1 Parametric
East Mill Street
South Broadway Street
E. Bowery Street
Quaker Square
Quaker Station
Grounds & Maintance
Thermal Storage Tank
Olson Research Center
Forge Street
SKIN